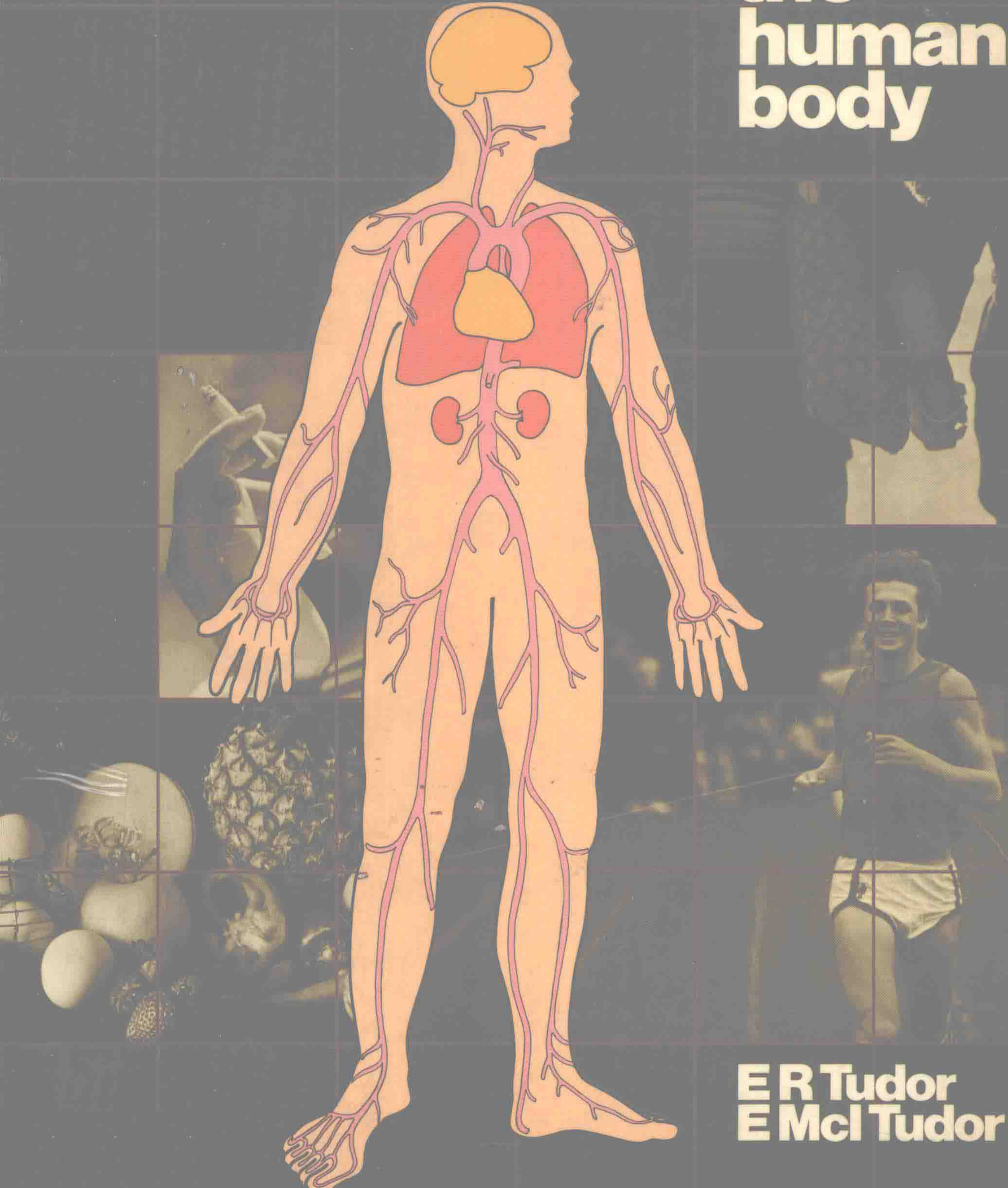
Understanding the human body



E R Tudor
E McI Tudor

Understanding the human body

E R Tudor MSc Dip Ed
E McI Tudor BVSc (Hons)

Illustrations by
Kate Crowle

Pitman

First published
in Australia 1981
Reprinted 1982, 1984

Pitman Publishing Pty Ltd
(Incorporated in Victoria)

158 Bouverie Street
Carlton
Victoria 3053

Level 11
Town Hall House
452–462 Kent Street
Sydney
New South Wales 2000

9th Floor
National Bank Building
420 George Street
Brisbane
Queensland 4000

Associated companies

Pitman Publishing Ltd
London

Copp Clark Pitman
Toronto

Pitman Learning Inc
Belmont, California

Pitman Publishing New Zealand Ltd
Wellington

National Library of Australia
Cataloguing in Publication data

Tudor, E. R. (Edward Richard)
Understanding the human body.

Includes index.
ISBN 0 85896 819 3.

1. Biology. I. Tudor, E.McI. (Elizabeth McIntyre).
II. Title.

574

Text set in English Times
by Richard Clay (SE Asia) Pte Limited

Printed and bound by
Koon Wah Printing Pte Ltd

Designed by Pauline McClenahan

Acknowledgments

The stimulus for this book came from a course in human and social biology introduced at Melbourne Church of England Grammar School by Mr Alan Patterson. To both the school and Mr Patterson we are indebted. Writing was begun during the latter part of a teaching exchange at King's School, Bruton, Somerset, in the United Kingdom. For the contribution that this teaching exchange made to the book we are most grateful.

A number of people read parts of the manuscript, and we thank them for their valuable suggestions: in particular Dr J N Santamaria, Mr J Cheetham, Mrs E Clements, Dr C R Hunter and Mr B Jones. For the preparation of scanning electron micrographs we are most grateful to Mr C Mayberry. Mr T Martin and Mr G Perkins assisted with the preparation of photographic material. Finally we thank particularly Mrs Barbara Gray for typing each draft of the manuscript with such interest and care.

We are grateful to the following for permission to reproduce copyright material: Blackwell Scientific Publications for Fig 7.14, redrawn from Fig 7.9 in I M Roitt, *Essential Immunology* (1971); The English Universities Press for Figs 6.6 and 6.11, redrawn from pp 65 and 66 of C H Barnett et al, *The Human Body* (1975); Miss Shirley Jennings for the extract in Chapter 19 from *Challenging Years*, a publication of the Australian Council on the Ageing; Macmillan Publishing for Fig 6.15, redrawn from Fig 15.2 in M Griffiths, *Introduction to Human Physiology* (1974); the Royal College of Physicians and Pitman Medical for Figs 9.1, 9.2 and 9.3, adapted from pp 44, 54 and 66 of *Smoking or Health*, 3rd edn (1977); Prentice Hall Inc for Fig 6.16, adapted from Fig 5.8, and Fig 13.14, redrawn from Fig 10.2, in R Macey, *Human Physiology*, 2nd edn (1975); the Road Safety and Traffic Authority of Victoria for Fig 16.8 (unpublished data, 1976); and W B Saunders Co for Figs 19.2, 19.3 and 19.4, adapted from D W Smith and E L Bierman (ed), *The Biologic Ages of Man* (1975).

ERT, E McI T

Contents

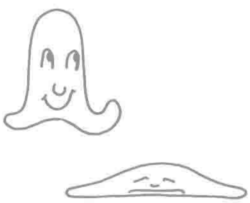
Chapter 1

The living world and how we view it

- Characteristics of living things
- Classifying the living world
- Humans and their place in the animal kingdom
- Human control of the environment

We don't need a great deal of imagination to appreciate that the earth is composed of an extremely large number and variety of things. A casual glance at our surroundings will reveal rocks, trees, buildings, mountains, flowers, animals, roads and so on. Each object has its own form, colour, texture and composition—the features by which we recognise it and give it a name.

Young children learn step by step to recognise objects and features of their environment and in turn to give them names. As this process of recognition develops, children learn subconsciously to place different objects in different groups. That is, the child learns to classify the objects in the world around him. Perhaps the first difference a child becomes aware of is that between 'mother' and 'not mother'. A little later, as the child becomes aware of more objects around him, he realises that some objects move, others are soft, warm or furry and some make characteristic noises. Other objects may be hard, immobile, shiny or cold. In this mental process the child is grappling with one of the most basic classifications of the world he lives in—he is making the distinction between living and non-living things.



Living or dead: how do we know?

Characteristics of living things

Biology is the study of living things. The word biology comes from two Greek words—*bios*, meaning life, and *logos*, meaning a study. What, then, are the characteristics of living things?

It is almost impossible to define life itself. It is not so difficult, however, to describe what living things are. This is because all living things have certain common characteristics. Some of these may also be found in some non-living things. For example, cars can move, and crystals may grow. However, only living organisms share all these characteristics.

We can demonstrate all of these characteristics in some of the very simplest forms of living things—tiny plants and animals, some made of a single cell and visible only under a microscope. The same living processes are basic to all forms of life, however. Although they may not be as easy to demonstrate, life depends on these same processes in trees, seaweed, mice and human beings.

Feeding

Feeding is probably one of the most obvious characteristics of living things. We are well aware that all living organisms feed—so many of the animals we can see around us appear to spend much of their time in search of food. Under a microscope we can observe tiny one-celled animals feeding on particles from their environment. Plants, too, 'feed' on molecules in the soil and air around them.

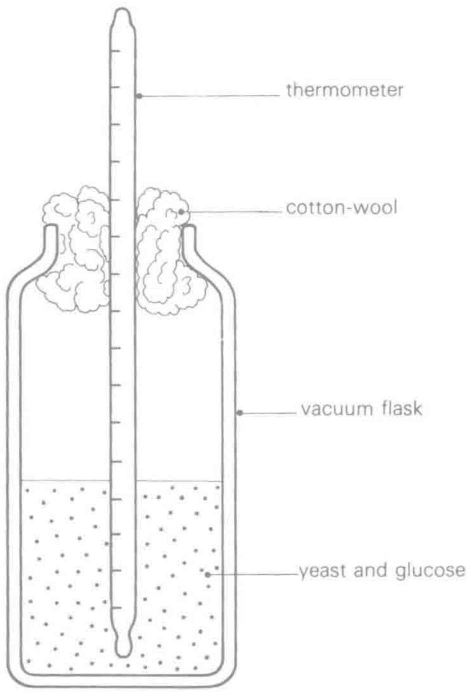


Fig 1.1 *Apparatus used to demonstrate respiration*

Living organisms use these 'food' molecules which they obtain from their environment to repair themselves and grow. They may also use them as a fuel, which they burn in chemical reactions, to release the energy they need for other life processes.

Respiration

Respiration—the release of energy

Experiment Yeast cells, tiny one-celled plants, are placed in a vacuum flask, in a solution of 0.1 per cent glucose. A thermometer is placed in the yeast–glucose suspension, and the top of the flask is closed with cotton wool (Fig 1.1). The temperature of the suspension is recorded. A second temperature recording is made after 24 hours. The concentration of glucose after 24 hours is found to be zero. The temperature of the suspension has risen considerably.

Explanation Yeast cells have used the glucose in a process called **respiration**. This is a chemical process which goes on inside all living organisms. It involves the chemical breakdown of glucose (sugar) to release energy. This chemical reaction can be summarised:

$$\text{Glucose} \xrightarrow{\text{yeast}} \text{energy} + \text{ethyl alcohol} + \text{carbon dioxide}$$

The energy is the most important part of this reaction. It is the energy that enables the yeast to carry on all its living functions:

- cell division (splitting) or reproduction
- building up its cellular structures (growth)
- breaking down unwanted structures and materials
- moving molecules into and out of the cell.

But why does the temperature increase in the vacuum flask? As the glucose is broken down, much of the energy in the glucose is trapped and used for the yeast's life processes. However, some of the energy escapes and is wasted. This waste energy becomes heat—hence the temperature increase.

During the breakdown of glucose in yeast cells, to release energy, two waste products are formed: ethyl alcohol (commonly referred to as alcohol) and a gas, carbon dioxide. Yeast cells break down sugar without using oxygen—this kind of respiration is called **anaerobic respiration.**

Most living organisms assist the breakdown of glucose by using oxygen. When oxygen is used, much more energy can be released. The process of breaking down glucose with oxygen is called **aerobic respiration**. Aerobic respiration is similar to anaerobic respiration in that glucose is broken down in order to release energy. However, instead of carbon dioxide and ethyl alcohol, the waste products of aerobic respiration are carbon dioxide and water. This reaction can be summarised as follows:

$$\text{Glucose} + \text{oxygen} \rightarrow \text{energy} + \text{carbon dioxide} + \text{water}$$

As in yeast cells, some of the energy resulting from this process is wasted as heat.

The human body is like a very complex machine. Huge amounts of energy must be provided all the time for the highly specialised life processes. Aerobic respiration provides most of the energy which the body cells need. However, sometimes oxygen cannot be supplied quickly enough to allow aerobic respiration to proceed. At these times, the cells must release energy from glucose without oxygen, that is by anaerobic respiration. This process is similar to anaerobic respiration in yeast cells. However, in all animals, the waste product of anaerobic respiration is lactic acid. The equation for anaerobic respiration in animal cells can be written:

$$\text{Glucose} \rightarrow \text{energy} + \text{lactic acid}$$

Excretion

Experiment Some milk is placed in a test tube and an indicator used to test its acidity. The milk is slightly acidic. The milk is left for 5 days at room temperature, and its acidity is tested again. The acidity of the milk has increased considerably.

At the same time, another sample of milk is placed in the refrigerator. The acidity of this milk also is tested at the beginning and the end of the 5-day period. The acidity of this milk has not increased.

Explanation Bacteria in the milk sample kept at room temperature have used up sugars in the milk to release energy. The waste product of this process is lactic acid.

As explained in the previous section, this process is known as anaerobic respiration. The bacteria have no use for the lactic acid. In fact, if it collects inside the cells in high concentrations it becomes poisonous or toxic. To overcome this, lactic acid is eliminated or excreted by the bacteria. Lactic acid is thus called an excretory product.

(In the milk kept in the refrigerator, very little lactic acid is produced. This is because bacteria are unable to continue energy-releasing reactions when the temperature is low.)

All living organisms excrete some kind of waste material. In humans, the waste product resulting from the breakdown of proteins is very toxic. It is converted into urea (Chapters 4 and 12), which is excreted through the kidneys. Carbon dioxide, the waste product of aerobic respiration, is excreted through the lungs (see Chapter 8).

Movement

Watch a number of small aquatic organisms moving under a microscope, for example paramecium, amoeba and euglena (Fig 1.2). Each of these organisms moves by a different method. Although our bodies, as a whole, are moved by more complex systems (discussed in Chapter 18), each of these simple types of movements is important in particular cells in our bodies.

Paramecium moves by means of rows of small hairs which are attached to its surface. These are called **cilia**. As the cilia beat, they propel the microscopic animal forwards or backwards. Cilia are also found in the gullet of the paramecium. Here, their beating action wafts tiny food particles into this small hollow, ready for 'swallowing' by the animal. (We shall see later that cilia have an important job moving different particles on several of our body surfaces, too.)

Amoebae move by quite a different process. You can think of an amoeba as being like a loose jelly (cytoplasm) inside a thin plastic bag (cell membrane). The jelly flows around inside the plastic bag, and occasionally pushes slightly harder in a particular direction. When it does this it forms a projection or **pseudopod** (false foot). The rest of the cytoplasm (jelly) may flow in the same direction, so that the whole amoeba is brought to a new position (Fig 1.2b). Because it was first described in the amoeba, this type of movement is known as **amoeboid movement**. In our bodies, certain types of white blood cells move through the tissues by this means (see Chapter 7).

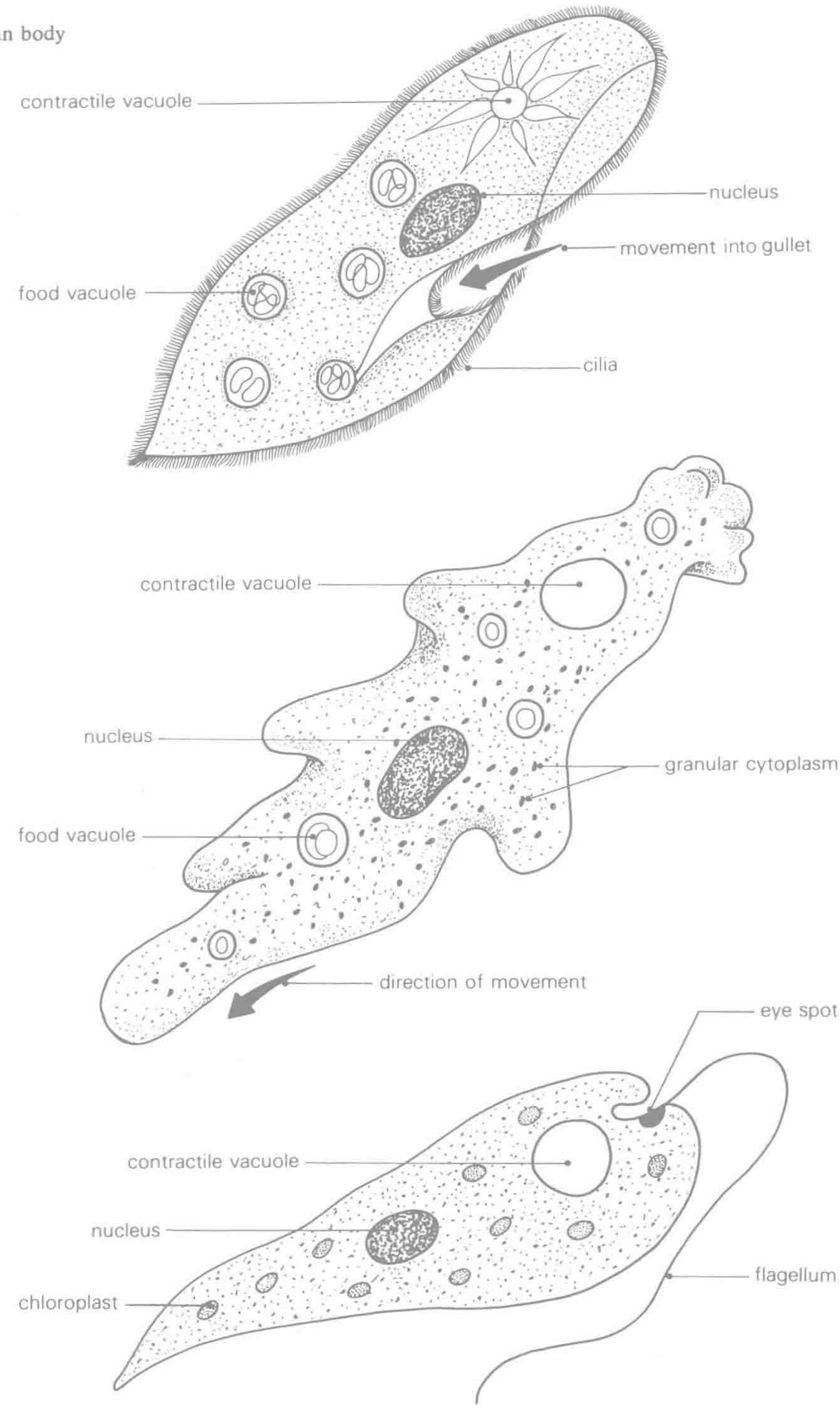


Fig 1.2 *Three small water organisms, each using a different method of locomotion*
(a) Paramecium (movement using cilia)
(b) Amoeba (movement using pseudopodia)
(c) Euglena (movement using a flagellum)

Many organisms move by means of a single, whip-like tail called a **flagellum**. As the tail lashes, the organism is propelled through the water. Euglena is an example of an organism that moves in this way (Fig 1.2c). Sperm cells (see Chapter 17) also move by means of a flagellum.

Reproduction

Experiment A yeast cell is placed on a cavity slide in a 0.1 per cent glucose solution at room temperature. (These cells can be handled using a very small pipette and a binocular dissecting microscope.) When the slide is examined under the dissecting microscope 24 hours later, a number of cells can be seen. The cell has multiplied. In biological terms we say that the yeast cell has reproduced.

Explanation How has this reproduction occurred? If you could observe the cells for some time under the microscope, you would see them form small side buds (Fig 1.3a). The small buds grow and then finally break off to form new individual cells. This very simple type of reproduction is known as **budding**.

Reproduction, the ability of an organism to create new organisms like itself, is a basic feature of all living things. It is not an essential part of the survival of an individual, but the survival of that species depends on at least some of the individuals of the species reproducing themselves. Reproduction by budding, which occurs in yeast cells, is one of the simplest forms of reproduction. There are several other types of reproduction.

Very simple organisms like bacteria (see Chapter 7) divide by a method known as **binary fission**. In this method, the bacterial cell grows longer, until it reaches a size at which it can divide into two portions. The nuclear (genetic) material separates into two parts, and then a new cell wall grows down the centre of the cell. Finally, the divided cell splits to form two new bacteria (Fig 1.3b).

Other one-celled animals, like the amoeba, can also reproduce by simple fission. However, the division is more complex. The process of cell division is called **mitosis**. The important feature of mitosis is that it ensures equal division of both nucleus and cytoplasm between the two 'daughter' cells (Fig 1.3c). Mitosis involves a complex sequence of events which are discussed in Chapter 5 and illustrated in Fig 5.1.

Mitosis occurs in all multicelled animals and plants. It is the process by which their cells divide. However, cell division of this type, in complex organisms, does not normally result in reproduction of a new daughter individual. Instead, cell division results in an increase in cell number and tissue volume, that is, in growth.

Reproduction by binary fission, budding and mitosis are all examples of reproduction in which the daughter organisms are identical to the parent organisms. This type of reproduction is called **asexual reproduction**. Reproduction of larger organisms such as humans involves a far more

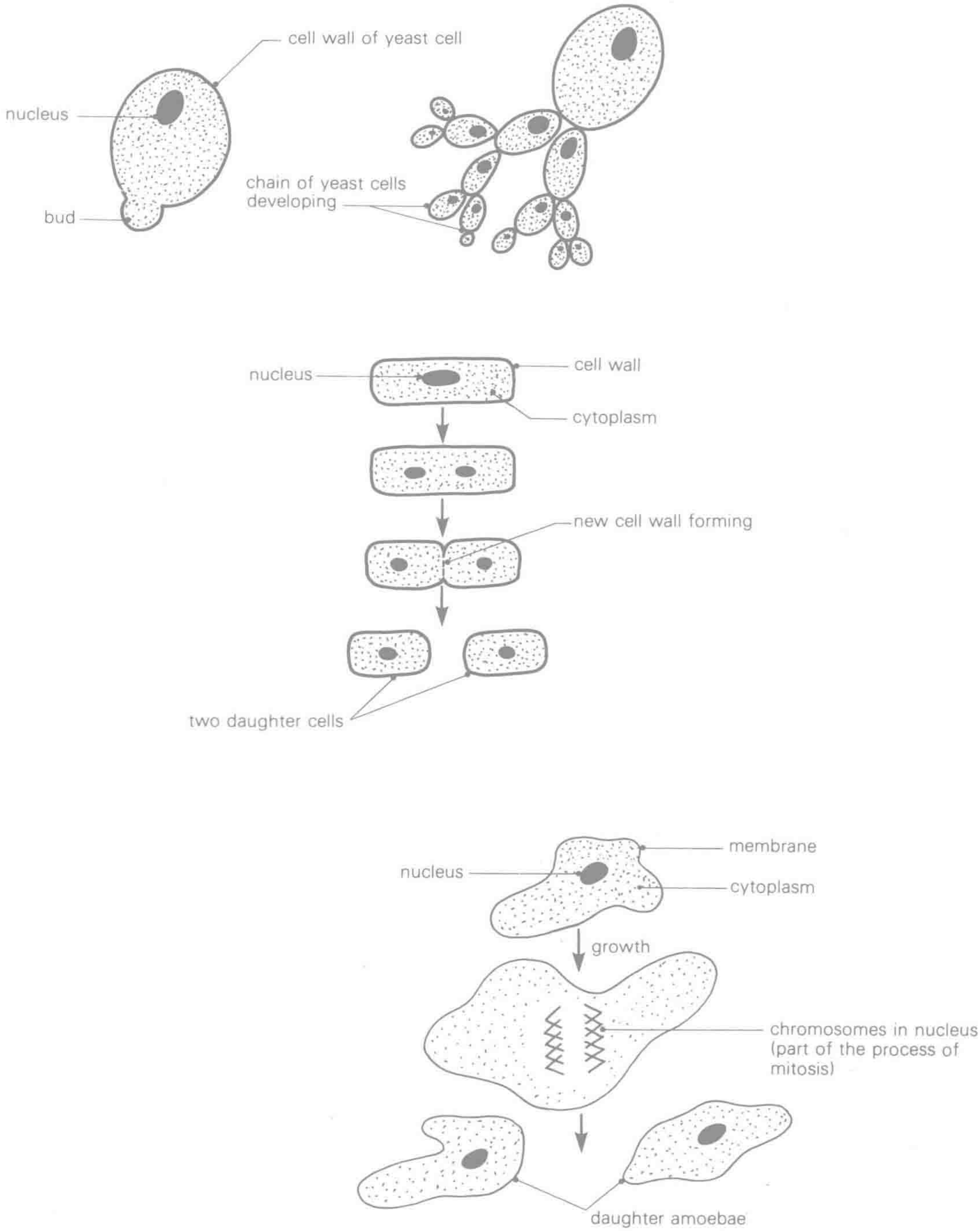


Fig 1.3 *Three methods of reproduction*
(a) Budding (yeast)
(b) Binary fission (bacteria)
(c) Division involving mitosis (amoeba)

complex process called **sexual reproduction**. Sexual reproduction differs from asexual reproduction in several important ways:

- The formation of the new individual begins with the union (fusion) of two cells. This union is called **fertilisation**.
- The two cells which fuse to form the new individual are called **gametes**.
- In animals, the gametes are always of two kinds—male and female.

The process of reproduction of the human species is discussed in detail in Chapter 17.

Irritability

Experiment A number of euglena (single-celled animals) are placed in a drop of water on a microscope slide. Part of the slide is illuminated, the other part remains in darkness. Very soon, most of the organisms are found on the illuminated part of the slide.

Explanation The organisms have responded to a change in their environment. In biological terms this change is called a **stimulus**. Because the euglena are able to detect the stimulus and respond to it, they are said to be **irritable**.

All living things, plants included, are irritable in some way. Different organisms are sensitive (or can respond) to different types of stimuli. You may have observed how a plant bends slowly towards *light* from a window in a dark room, or how a tendril of a climbing plant curls in response to *touch*. Woodlice move away from light, and moths fly towards it. People, of course, can detect and respond to a huge variety of stimuli—they have special communication systems which enable them to do this. These are discussed in detail in Chapters 13 and 15.

Classifying the living world

The biologist classifies living organisms by grouping them according to their permanent and useful characteristics. For example, the kingdom of animals can be broken up into smaller, but still very large, groups called phyla (singular phylum), into which are placed animals with similar characteristics. The animals which make up a phylum can be split into a number of smaller groups called classes. Classes can in turn be subdivided into: orders, families, genera (singular genus) and finally into the smallest category, the species.

Every organism is given a name according to the genus and species groups it belongs to. Because organisms belonging to the same genus and species groups possess particular characteristics, knowing the genus and species name of an organism tells us a great deal about the organism.

Figure 1.4 illustrates this process of classification by showing the place of humans amongst living things.